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Diameter and Basal Area Distributions in Old-Growth Spruce-Fir Stands in Colorado

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Old-growth spruce-fir stands on the Fraser Experimental Forest, Colorado, were found to be irregularly uneven-aged. Although subalpine fir trees were most numerous, most of the basal area was Engelmann spruce. Alternatives to current cutting methods are suggested for stands with similar structures.

Keywords: *Picea engelmannii, Abies lasiocarpa*, stand structure, silviculture, mensuration

Management Implications

The diameter and basal area distributions, and composition of the stands sampled on the Fraser Experimental Forest are representative of many multi-storied spruce-fir stands in Colorado. This structural arrangement suggests some alternatives to current cutting methods.

The uneven-aged silvicultural system using either individual tree or group selection cutting methods or a combination of the two, should be successful in maintaining spruce-fir stands with similar structures. These cutting methods are consistent with the natural dynamics of these stands. On sites and in situations difficult to regenerate with clearcutting (Alexander 1984), individual tree and group selection cutting methods provide a continuing seed source and an environment compatible with continuous reproduction. The manager must provide suitable seedbed conditions—mineral soil. There are some drawbacks to uneven-aged management. The proportion of reproduction that is subalpine fir probably will always be similar to that in natural, unmanaged, multi-storied stands; this means that cutting to maintain the diameter distribution in the smaller size classes should favor spruce over fir. The costs of sale layout, marking, and administration also will be more expensive than clearcutting, especially the care that must be exercised in logging to minimize damage to the residual stand.

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Even-aged management with either standard shelterwood or clearcutting in small (3- to 5-acre) patches is the preferred alternative for spruce-fir forests in most Forest Plans in the central Rocky Mountains. Neither is really compatible with the stand structure described in this note. If even-aged management is the goal, a better alternative would be a simulated shelterwood cut that removes the overstory from a manageable understory. Some stand improvement which removes trees in the 4- to 7-inch d.b.h. classes usually is needed to put the residual stand in an even-aged condition. Much of the timber harvesting in spruce-fir forests in the central Rocky Mountains has been a simulated shelterwood, even though it has been referred to as clearcutting. Good examples are the timber harvesting on the Fool Creek and Deadhorse Creek watersheds (Alexander 1968, Troendle 1983). Drawbacks to simulated shelterwood are similar to those for uneven-aged cutting methods. The residual stands are likely to contain a high proportion of fir, and extreme care must be exercised in logging to save the residual understory.

Introduction

Prompt establishment of natural regeneration after timber harvest in Engelmann spruce (*Picea engelmannii* Parry ex. Engelm.)-subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) forests is a major management objective in the central Rocky Mountains. These forests usually have been harvested with even-aged methods—either clearcutting or shelterwood. The diversity in age-class struc-

ture coupled with the harsh environment where spruce and fir grow (Alexander 1974, Alexander and Shepperd 1984, Haeffner 1971) have strong ecological implications that may be largely responsible for the variability in natural regeneration success with even-aged methods. In general, lower elevations (below 10,000 feet) and north and east aspects have been the easiest to regenerate, especially with the shelterwood method. Higher elevations (above 10,000 feet), and south and west aspects have been the most difficult to regenerate, especially with clearcutting (Alexander 1984, Noble and Alexander 1977).

The even-aged silvicultural system may not always have been compatible with the age-class structure, regeneration requirements, and development of stands in spruce-fir forests. This note examines the age-class structure and development of old-growth stands on the Fraser Experimental Forest in Colorado, and suggests some alternatives to timber harvesting methods commonly used in spruce-fir forests in the central Rocky Mountains.

Study Area

The Fraser Experimental Forest is a 23,000-acre tract, about 50 air miles from Denver, Colo., on the west side of the Continental Divide (Alexander and Watkins 1977). About 75% of the Forest is above 10,000 feet elevation, and about 33% is above timberline. Spruce-fir stands on the forest are typical of those forests growing

Figure 1.—Stand diameter distribution by species.

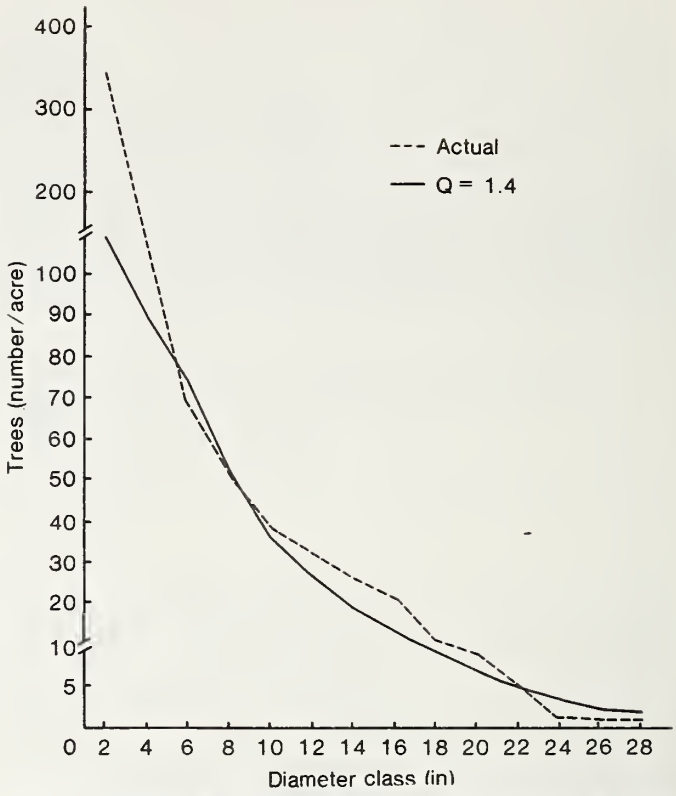

Figure 2.—Actual diameter distribution for all trees, and an idealized diameter distribution curve based on stand structure goals.

at high elevations in the mountains of Colorado. All stands sampled were in old-growth forests in the *Abies lasiocarpa/Vaccinium scoparium* habitat type, the most common spruce-fir habitat type found in Colorado. Undergrowth vegetation in this habitat type does not compete as severely with tree reproduction as in other habitat types. Stands cover a range of elevations (9,100 to 11,400 feet), aspects (N10°W to S20°E), slope (5 to 30%) and site quality (55 to 82) (table 1). Average age of dominant spruces vary from about 190 to 290 years at breast height. Soils are coarse-textured sands and gravels with very little silt and clay, derived principally from gneiss and schist rocks.

Methods

Thirteen 0.4-acre sample plots established for a spruce seed production study (Alexander et al. 1982) provided the diameters, by species, of all trees on each plot 3.6 inches d.b.h. and larger. Reproduction and trees 0.5 to 3.5 inches d.b.h. were tallied by size class and species on 20-milacre subplots in each plot. Except for the six site trees sampled on each plot, no ages were determined. Diameter, not age, is a more relevant variable in old-growth spruce-fir stands. However, at least four broad age classes were observed—reproduction less than 4.5 feet tall, trees 1 to 3 inches d.b.h., trees 4 to 7 inches d.b.h., and trees 8 inches d.b.h. and larger. Basal area per acre was computed from the diameter and tree data.

Table 1.—Characteristics of study plots, Fraser Experimental Forest, Colorado.

Plot number	Location	Elevation	Aspect	Slope	Site index[1]	Average age dominants at breast height
		--feet--		*-percent-*		*---years---*
1	Deadhorse Creek	9,140	N45°E	5	58	292
2	Deadhorse Creek	9,120	N45°E	5	68	280
3	Fool Cr.	11,400	N25°E	5	42	250
4	Fool Cr.	10,820	N10°W	12	61	247
5	Fool Cr.	10,670	N10°E	15	50	242
6	Fool Cr.	10,000	N25°E	12	65	246
7	W. St. Louis Cr.	10,000	S50°E	25	70	289
8	W. St. Louis Cr.	9,520	Due E	5	78	283
9	W. St. Louis Cr.	9,560	Due N	30	64	291
10	Short Cr.	9,400	N15°E	18	66	269
11	Short Cr.	9,365	N50°W	13	77	246
12	Main St. Louis Cr.	9,800	S20°E	5	55	284
13	E. St. Louis Cr.	9,500	N10°W	5	82	192

[1]*Taken from Alexander 1967.*

Diameter and basal area distributions for spruce and fir were plotted for each sample stand. Examination of these data indicated that the same trends, including species composition, were evident on each plot; therefore, data from all plots were combined to increase the data base.

Results and Discussion

Diameter distributions of both spruce and fir followed the same general trend (fig. 1). There were many trees in the small size classes; about 75% of the trees were less than 1 inch d.b.h. and about 90% were less than 4 inches d.b.h. (table 2). The diameter distribution of both spruce and fir—regardless of the age of individual trees—has the appearance of an uneven-aged or irregular stand structure. This is more evident when compared with stand structure goals for regulating growing stock under uneven-aged cutting methods. For example, with maximum diameter (28 inches) and average stocking (200 square feet basal area per acre) attained in these stands, the diameter distribution of all species closely approximates a q value of 1.4 (fig. 2) (Alexander and Edminister 1977).

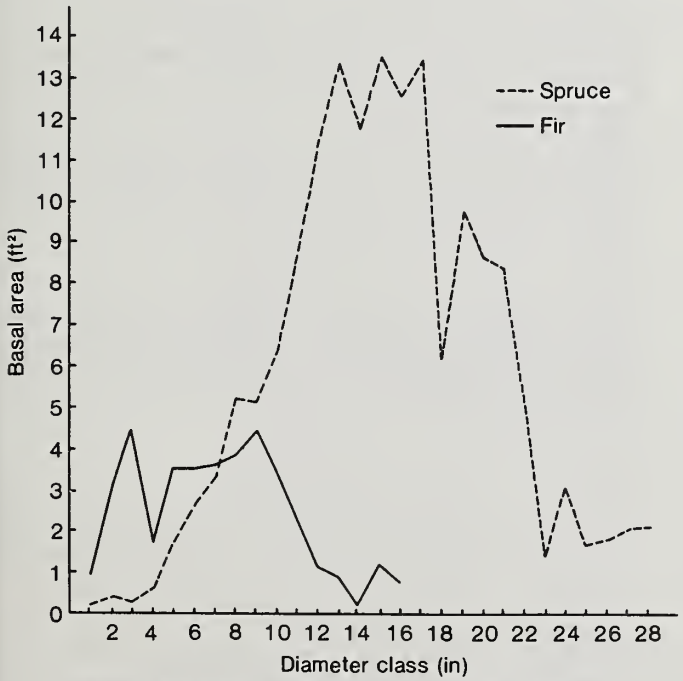

Figure 3.—Basal area by diameter class and species.

Tree density was relatively high—about 3000 stems per acre. Subalpine fir was the dominant species, accounting for about 75% of the total stand (table 2). The large number of seedlings and small saplings, with the preponderance being subalpine fir, is in general agreement with most comparable studies (Alexander 1974). Subalpine fir is less exacting in its seedbed requirements and is able to survive lower light intensities than Engelmann spruce (Alexander and Shepperd 1984). Conversely, Engelmann spruce was dominant in the larger diameter classes, nearly four times as many spruces as firs were in the 8-inch d.b.h. and larger size classes.

Engelmann spruce accounted for 80% of the total basal area (fig. 3). The larger number of trees in the 8-inch d.b.h. and larger diameter classes accounted for the higher spruce basal area (table 2). Subalpine fir, despite its higher density, had relatively low basal area, because most of the fir trees were in the reproduction and small diameter classes. The largest fir tree was in the 16-inch diameter class, whereas Engelmann spruce reached a maximum diameter of 28 inches d.b.h. These data agree with most observations in spruce-fir stands. Spruce usually makes up 70% to 90% of the basal area (Alexander 1974).

Spruce-fir stands sampled on the Fraser Experimental Forest are in a steady state with their environ-

Table 2.—Number of trees and basal area (square feet) per acre by species and size class (diameter at breast height, inches).

Size class	Spruce		Fir		Total	
	Trees	BA	Trees	BA	Trees	BA
<1	550	0	1,782	0	2,332	0
1-3	77	0.93	388	8.22	465	9.15
4-7	46	8.35	77	12.37	123	20.72
8+	141	151.86	35	18.26	176	170.12
All	814	161.14	2,282	38.85	3,096	199.99

ment. Engelmann spruce and subalpine fir are co-climax overstory species. Engelmann spruce maintains its dominant position in the overstory because it is long-lived and reaches greater sizes. Moreover, it is able to reproduce in these stands on suitable microenvironments—mineral soil seedbeds and partial shade—in sufficient numbers to maintain its representation. Subalpine fir, while able to reproduce on a wider variety of seedbeds under a spruce overstory, will not be able to supplant the dominant spruce, because its pathologic rotation is only about one-half that of spruce.

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